Key West Harbor Turbidity Monitoring for September 2001

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Executive Summary

Turbidity and other water quality parameter measurements were made at 15-minute intervals at six locations in and around Key West Harbor in order to document turbidity in Key West Harbor, the turning basin, and surrounding areas. Variables such as the presence of ship traffic, tidal cycle, and weather were also monitored to seek a qualitative sense of their contributions to turbidity levels. Monitoring began September 24 and ended September 29, 2001. Monitoring stations were selected to provide data along the ship channel and turning basin, as well as areas less likely to be affected by ship traffic. Ship traffic and tide data were obtained and plotted with turbidity levels. All data were tabulated and appended to the report.

In addition to the September 2001 water quality monitoring described above, 10 sediment samples were collected from the harbor. These samples were archived at PPB Environmental Laboratories, Inc. for possible future analysis.

During the sampling period, there were nine ship movements and two periods of unsettled weather. The ship movements were at 1500 Eastern daylight time (EDT) 9/24, 0800 EDT 9/25, 1400 EDT 9/25, 0900 EDT 9/27, 1800 EDT 9/27, 0730 EDT 9/28, 1000 EDT 9/28, 1400 EDT 9/28, and 1530 EDT 9/28. Unsettled weather associated with rainfall and the passage of fronts through the area occurred during the middle of the day on 9/25 and 9/26, and the evening of 9/28 into 9/29.

Turbidity levels were generally less than seven nephelometric turbidity units (NTU), with three stations measuring less than two NTU most of the time. Ship arrivals and departures showed some correlation with elevated turbidity levels at Station KW1 at the end of the mole and possibly at Station KW2, across the turning basin adjacent to Tank Island. Turbidity levels at these stations never exceeded 40 NTU during ship movements, and turbidity levels returned to normal within minutes. Stations KW3 (near Key West Bight) and KW6 (Northwest Channel) showed no response to ship movement. Station KW5 (between KW2 and KW6) showed variations that appear unrelated to ship movements. A turbidity peak measured at Station KW4 (north of Frankfort Bank) between 1115 and 1500 EDT on 9/25 does not appear to be related to a ship departure at 1400 EDT. The turbidity plumes associated with ship movement appear to dissipate more quickly than weather-generated turbidity. The data indicate that 15-minute sampling intervals may be too long a period to capture the full profile of turbidity events associated with ship movement. Turbidity during rough weather conditions appeared to have a much stronger and more general impact with some measurements exceeding 50 NTU.

The monitoring data show generally low levels of turbidity in the Key West area during calm weather and higher levels during periods of more active weather. The limited data do not allow definitive statements regarding the relative importance of weather in producing turbidity in the harbor area, but indicate that weather may generate significantly greater turbidity than ship movements, both in extent and persistence of the event. When compared to turbidity attributed to weather, ship movement appears to have a smaller and shorter-lived impact on turbidity levels, even in the immediate vicinity of the ships. Weather information was not sufficiently detailed to discriminate between turbidity produced by wave action and other sources such as turbidity created by stormwater flow from the land.

This investigation provides valuable information concerning turbidity generated by ship movement and weather but does not provide definitive answers regarding the other possible origins of turbidity. To fully understand non-cruise ship generated turbidity around Key West, a

follow-up study would need to consider the rate of tidal flows in the harbor area, optimization of monitoring variables to better resolve peaks and movement of turbidity plumes caused by ship traffic, and the need for relevant local weather data. In order to discern turbidity plume development, movement, and dispersal, monitoring stations should be established in or near the entrance channel Cut "B", the Key West Harbor Range, ship docking areas, and the turning basin. At least one "background" location, possibly in the Northwest Channel, would need to be monitored. The monitoring interval should be reduced from 15 minutes to 1 to 2 minutes to better resolve turbidity changes so that the recording of any peak turbidity values are not missed because of water displacement caused by tidal flow between readings.

Weather conditions to be monitored are the wind speed, wind direction, and rainfall. Current monitors or neutrally buoyant floats would be very useful if deployed along the natural and manmade channels to allow modeling of the water movement during tidal cycles and observing the effects of persistent winds. Wave monitors may be useful but are of secondary value in this environment. It would also be important to identify areas with natural resources that can be damaged by excessive levels of turbidity relative to the harbor and areas of ship traffic. Such areas should be considered when locating any future monitoring stations as a means of measuring direct impacts.

Introduction

This monitoring program was designed to establish a baseline for turbidity levels in Key West Harbor and turning basin and surrounding areas. At six locations, turbidity measurements were made at 15-minute intervals beginning September 24 and ending September 29, 2001.

In addition to turbidity monitoring, sediment samples were collected from 10 locations within the harbor. These samples were archived for possible future analysis.

Methods and Procedures

Six stations were selected as locations for turbidity monitoring; these were identified as Stations KW1 through KW6. These stations were located at fixed structures to which Hydrolab® DataSonde 4a units were attached. Three Hydrolabs® were attached to fixed channel markers constructed from iron "I" beams in the Northwest Channel and the turning basin. One unit was attached to a navigational buoy at the south end of Tank Island. (It should be noted that U.S. Coast Guard approval was obtained before securing these devices to their structures.) Another Hydrolab® was fixed to a ladder at the "north mole" and the sixth was secured to an existing pipe that extended above the water surface north of Wisteria Island.

Hydrolabs® were calibrated in accordance to the manufacturer's specifications and the Water and Air Research, Inc. (Water & Air) Comprehensive Quality Assurance Plan (Florida Department of Environmental Protection approved CompQAP# 900211). Turbidity probes were calibrated using filtered deionized water and formazin suspensions of 50 and 100 Nephelometric Turbidity Units (NTUs). The multi-parameter instruments also measured temperature, pH, conductivity, salinity, dissolved oxygen, and, for some units, sensor depth. When practicable, each Hydrolab® was retrieved daily for data downloading and to verify readings (i.e., specifically turbidity but also conductivity and salinity) using filtered deionized water. Post-use calibration checks were performed for all parameters requiring calibration.

When deployed, water quality sensors were positioned to be approximately 2 feet below the water surface at low tide. Units were secured to prevent them from being battered against the structures by waves.

Information regarding cruise ship arrivals and departures was supplied by the city of Key West. Verified tidal height information was obtained from The Center for Operational Oceanographic Products and Services, which is part of the National Oceanographic and Atmospheric Administration's National Ocean Service.

Sediment samples were collected using a stainless-steel petite ponar sampler. This device was decontaminated before collecting each sample using laboratory-grade detergent and pesticide-reagent grade isopropanol as specified in the Water & Air CompQAP. Each collected sediment was placed in a stainless-steel bowl and homogenized with a stainless-steel spoon before being placed in the laboratory-supplied sample container. All spoons and bowls were appropriately decontaminated before use.

Sediment sampling Station E-KW01-2 was sampled in duplicate. After collecting the routine sample from this station, additional ponar grabs were collected, homogenized, and placed into sample containers identified as E-KW01-2 Dup.

All sampling and monitoring locations were documented using a Global Positioning System receiver with Wide Area Augmentation System (WAAS) correction.

Results and Discussion

Station locations are shown in Figure 1. Cruise ship berthing occurred at the north mole where Station KW1 was located and at the closest pier northeast of the north mole. Because most stations were serviced during falling tides, the anticipated directions of flow during rising tides were estimated and these are shown on Figure 2. Any plumes of turbid water originating from the harbor might be expected to move during rising tides in the directions indicated.

Pre-use calibrations and interim and post-use calibration checks indicate that all Hydrolab® units functioned without problems. Cleaning the turbidity sensor on the unit at Station KW1on September 28, 2001, appeared to lower *in situ* sensor readings by approximately 2 NTUs.

Turbidity and tide data for each station are plotted on Figure 3. The units at Stations KW3 and KW6 were quite consistent with turbidity readings that were mostly zeros. On September 29, 2001, a small craft advisory was issued to warn small craft to stay in port. This sea state is reflected by the increase in turbidity that was visually discernible at all stations. Only the unit at Station KW3 did not show an increase in turbidity measurements during this time.

Sediment sampling locations are shown in Figures 4 and 5. Attempts were made to collect sediments at many locations from which no sediments could be retrieved with the petite ponar. These locations appeared to have hard, rocky bottoms or have large rocks with no fine particulate sediment associated with them.

Turbidity monitoring and sediment sampling station locations in degrees and minutes (NAD83 projection) are as follows:

Station	Latitude	Longitude
KW1	N24 33.317	W81 48.625
KW2	N24 33.523	W81 48.902
KW3	N24 33.765	W81 48.341
KW4	N24 34.878	W81 48.648
KW5	N24 34.039	W81 49.732
KW6	N24 34.477	W81 50.581
E-KW01-1	N24 33.019	W81 48.779
E-KW01-2	N24 33.511	W81 48.793
E-KW01-3	N24 33.422	W81 48.894
E-KW01-4	N24 33.369	W81 48.587
E-KW01-5	N24 33.506	W81 48.521
E-KW01-6	N24 34.034	W81 48.412

Station	Latitude	Longitude
E-KW01-7	N24 34.171	W81 48.314
E-KW01-8	N24 34.064	W81 48.116
E-KW01-9	N24 33.910	W81 48.154
E-KW01-10	N24 34.017	W81 48.191

Appended to this report are copies of:

- turbidity monitoring (Hydrolab®) and sediment sampling field sheets
- sediment sample chain of custody form
- tabularized Hydrolab® data for each station